FOREIGN POLICY REPORTS

November 15, 1940

Defense Economy of the United States

An Inventory of Raw Materials

BY J. C. deWILDE and GEORGE MONSON

PUBLISHED TWICE A MONTH BY THE

Foreign Policy Association, Incorporated

MIDSTON HOUSE, 22 EAST 38th STREET, NEW YORK, N. Y.

VOLUME XVI NUMBER 17 *25¢ a copy* *$5.00 a year*

Defense Economy of the U.S.: An Inventory of Raw Materials

By J. C. deWilde and George Monson*

THE degree to which a country must control and direct its economic life in preparation for war depends in large part on its natural resources.[1] Because Nazi Germany lacked many of the essential war materials, it had to set up a closely regimented economy designed to conserve and ration available supplies, develop substitutes and lay in reserve stocks. The United States does not need to take such sweeping measures. While by no means able to satisfy all its requirements from domestic production, this country is exceptionally wealthy in raw materials. In many respects we are even more self-sufficient than in the first World War. Chemistry has given us new fibers like nylon and vinyon, synthetic camphor and rubber, resins and plastics, and magnesium. It has substantially decreased our dependence on imported natural nitrates and foreign medicinal and pharmaceutical products. We have made great strides in the production of potash and the recovery of iodine. Progress in metallurgical technique has increased the extent to which metals can be substituted for each other and facilitated the utilization of low-grade domestic ores. Home production of platinum and sulphur has greatly increased. On the other hand, time has further exhausted our meager deposits of certain minerals; and progress in the use of alloys, tin and aluminum has made us more dependent on foreign supplies of manganese, chrome, nickel, tin and bauxite.[1a]

OIL AND GAS

The United States and the Soviet Union are the only two countries fortunate enough to have adequate supplies of the three major essentials for modern industry and warfare—petroleum, coal and iron ore. Petroleum and natural gas have been of growing importance in the United States as a source of power, accounting in 1937 for 42.6 per cent of the total energy output.[2] Oil propels the tanks, aircraft and trucks of our armed forces, all the vessels of our Navy, and over 90 per cent of the tonnage of our ocean-going merchant marine. Moreover, petroleum supplements coal as a source of many vital raw materials such as synthetic rubber, acetone, ethyl alcohol and, above all, toluol, the basic ingredient of TNT.

The United States will have an adequate supply of petroleum even in the event of war, when demand is expected to increase by one-fourth.[3] We have produced on an average about 61 per cent of the total world output in the last five years[4] and possess 59 per cent of the refining capacity of the world.[5] Despite the high level of consumption, refineries in the last three years have been operating at only 78 to 83 per cent of capacity. A considerable reserve margin is therefore available for emergency purposes.

*Mr. Monson is a consulting economist.

1. This is the second in a series of studies on the economic aspects of national defense. The first was "Defense Economy of the United States: Problems of Mobilization," *Foreign Policy Reports,* November 1, 1940. Subsequent issues will deal with industrial capacity, labor, power and transportation.

1a. The degree of progress we have made appears to be reflected in the list of strategic and critical materials issued by the Army and Navy Munitions Board. The last list, dated March 1940, includes only 14 strategic materials, as compared with 42 in the first list of 1921. In the Board's classification, "strategic materials" are those for which the United States is wholly or largely dependent on foreign supplies. Included in this category are: antimony, chromium, coconut shell char, manganese (ferro-grade), manila fiber, mercury, mica, nickel, quartz crystal, quinine, rubber, silk, tin and tungsten. In addition, the Board lists fifteen "critical materials" the procurement of which is less difficult "either because they have a lesser degree of essentiality or are obtainable in more adequate quantities from domestic sources." These are: aluminum, asbestos, cork, graphite, hides, iodine, kapok, opium, optical glass, phenol, platinum, tanning materials, toluol, vanadium and wool. Army and Navy Munitions Board, *The Strategic and Critical Raw Materials,* March 1940.

2. At the end of 1937 86 per cent of the entire installed horsepower in the United States, including automobiles and other mobile power units, depended on petroleum products for energy. National Resources Committee, *Energy Resources and National Policy* (Washington, January 1939), pp. 123-24.

3. *Ibid.*, p. 28.

4. U.S. Bureau of Mines, *Crude Petroleum and Petroleum Products, Review of 1939,* p. 3. U.S. output of crude oil in 1939 was 1,264,256,000 barrels, as compared with world production of 2,076,772,000. Our net exports of crude amounted to 38,987,000 barrels, and of refined products to 91,105,000 barrels.

5. *Ibid.*, p. 50. The capacity of all U.S. refineries at the beginning of 1940 was 4,528,646 barrels of crude per day. In July 1940 operations were at the rate of 3,480,700, or about 75 per cent. Cf. U.S. Bureau of Mines, *Petroleum Refineries, including Cracking Plants in the United States, January 1, 1940,* and *Monthly Petroleum Statement No. 200.*

FOREIGN POLICY REPORTS, VOLUME XVI, NUMBER 17, NOVEMBER 15, 1940

Published twice a month by the FOREIGN POLICY ASSOCIATION, Incorporated, 22 East 38th Street, New York, N. Y., U.S.A. FRANK ROSS MCCOY, *President;* WILLIAM T. STONE, *Vice President* and *Washington representative;* VERA MICHELES DEAN, *Editor* and *Research Director;* HELEN TERRY, *Assistant Editor. Research Associates:* T. A. BISSON, A. RANDLE ELLIOTT, LOUIS E. FRECHTLING, JAMES FREDERICK GREEN, HELEN H. MOORHEAD, DAVID H. POPPER, ONA K. D. RINGWOOD, JOHN C. DEWILDE. Subscription Rates: $5.00 a year; to F.P.A. members $3.00; single copies 25 cents. Entered as second-class matter on March 31, 1931 at the post office at New York, N. Y., under the Act of March 3, 1879.

Produced under union conditions and composed, printed and bound by union labor.

AVIATION FUEL

The chief problem for the United States is to produce sufficient fuel of a high octane or anti-knock value.[6] Production figures on aviation gasoline have been available only since October 1939. In the 11-month period ending August 30, 1940 the United States produced 10,057,000 barrels, of which one-third was exported. Output rose from 859,000 barrels in October 1939 to a record of 1,094,000 barrels in July 1940.[7] Even in the latter month, however, it represented only 2.18 per cent of the entire motor fuel output. Although production capacity has so far exceeded demand,[8] requirements will rise sharply as the Army and Navy approach their 1942 goal of about 25,000 planes, and particularly the ultimate objective of 50,000 planes set by the President. It has been estimated that with an air force of 50,000 planes, peace-time training operations alone would require a daily consumption of 2 million gallons, as compared with only 137,000 gallons in the last fiscal year. For actual combat, of course, the demand would be much greater.[9] According to Dr. Robert E. Wilson, oil expert on the staff of the Defense Commission, the production of ordinary aviation gasoline of 92 or lower octane presents no problem, but special attention must be devoted to increasing the output of 100 octane fuel.[10] Meanwhile the licensing of exports, together with the embargo on all shipments outside the Western Hemisphere,[11] is designed to conserve the existing supply; and the Defense Supplies Corporation is purchasing a reserve stock for the Army and Navy.

Aviation fuel is commonly made through the admixture of blending agents and tetraethyl lead to a base stock of straight-run gasoline. Two things are necessary: crude oils that have the properties demanded in aviation gas and can be distilled into a gasoline with an octane rating of at least 73; and the equipment essential for the making of the high-octane blending agents. Although only a small proportion of crudes can be utilized, the United States probably has an ample supply for all future needs. If demand rises sharply, it may prove necessary to segregate suitable crudes for aviation use. The blending agents are manufactured by various synthetic processes known as polymerization, alkylation and catalytic cracking, all of which require expensive equipment.[12]

Techniques in the production of high-grade fuel are at present in a state of rapid development, with American refiners in a position of unquestioned world leadership. Rapid progress is being made not only in developing new blending agents, but above all in devising methods for the synthetic production of higher octane base stocks which are a considerable improvement over straight-run gasoline. The more important of these processes employ as raw material natural and refinery gases of which the United States has a large unutilized supply.[13] Meanwhile, the major oil companies are already constructing many new units to produce high-quality gasolines; and it is expected that the industry can

6. The production of gasoline for airplanes is an exacting task. The gasoline must have just the correct volatility and vapor pressure, a low freezing point, excellent stability (freedom from gum), and low sulphur content. Above all, it must have a very high anti-knock value, or octane rating. The octane value of a fuel is determined by comparing it with various mixtures of two materials—heptane, which has a zero rating, and iso-octane which has been arbitrarily given a value of 100 octane. Only during the last decade have high-octane gasolines been developed. The octane rating of regular motor gasoline has steadily improved from about 60 in 1931 to 74 in 1939. (*Industrial and Chemical Engineering,* June 1940, pp. 418-19.) Today it is possible to produce gasolines of 100 octane and over. The U.S. Army requires 100 octane gasoline for its combat planes, and fuel of somewhat lower quality for its training craft. The use of 100 octane fuel has marked advantages over the regular aviation grade of 87 octane. In the powerful, high-compression plane engines of today it lowers fuel consumption by 12 to 15 per cent, and makes possible a 30 per cent increase in power output, reducing take-off distances by 20 per cent and raising climbing speed by 40 per cent. (Gustav Egloff, "Petroleum Research Steadily Broadens Horizon of Oil Industry," *Chemical Industries,* June 1940.)

7. U.S. Bureau of Mines, Division of Information, *Aviation Gasoline,* October 1939, December 21, 1939, and *Monthly Petroleum Statement No. 201.*

8. The Information Service of the Department of Interior reported on August 3, 1940 that, with an average production of about 900,000 barrels per month from October 1939 to May 1940 inclusive, only 60 per cent of the capacity of refineries was utilized.

9. Cf. N. S. Norman, "Refineries Alert to Potential Need for Aviation Fuel," *Oil and Gas Journal,* June 13, 1940.

10. National Defense Advisory Commission, *Press Release 27,* July 9, 1940.

11. While the embargo affects only aviation gasolines of an octane rating of more than 87, the licensing requirements apply also to any gasoline or hydrocarbon mixture which, with the addition of 3 c.c. of tetraethyl lead per gallon, will exceed an octane rating of 87, and to any material, including crude oil, from which more than 3 per cent of such gasoline or hydrocarbon mixture can be derived by commercial distillation. In practice, most of our exports of crude oil and gasoline are now licensed.

12. The blending materials most commonly used are iso-octane and iso-pentane, though a new compound, known as neohexane, promises to be of increasing importance, particularly in the manufacture of fuels with an octane rating as high as 110-115. The normal 100 octane aviation gas consists of about 50 per cent straight-run gasoline, 40 per cent iso-octane, 10 per cent of iso-pentane, and a little tetraethyl lead, which, when used in very small quantities (about 3 c.c. per gallon) can increase the octane rating of the mixture to a remarkable degree. Cf. W. H. Hubner and Gustav Egloff, "Aircraft Fuels and Lubricants"; also address by Professor A. W. Nash before the Northern Branch of the Institute of Petroleum in Manchester, England, January 25, 1940; and "Aviation Fuels and their Manufacture," *Petroleum Press Service,* March 15, 1940.

13. It has been estimated, for example, that these gases are a potential source of 8,345,000,000 gallons 81 octane, or 3,275,000,000 gallons 92 octane, unleaded gasoline, which, in turn, with the addition of blending agents and tetraethyl lead, could be made to yield 6,000,000,000 gallons of 100 octane fuel. Cf. *National Petroleum News,* November 14, 1939.

keep pace with the growing needs of the defense program.[14]

COAL AND COKE

This country can undoubtedly produce enough coal to meet the additional fuel requirements of the munitions industries. For many years the coal industry has in fact suffered from chronic overcapacity, due primarily to cut-throat competition, progressive economies in fuel consumption, and increased competition from oil and natural gas.[15] Coal shortages in the last war were due not to insufficient production, but to congested transportation facilities. For national defense a sufficient supply of coking coal is particularly vital. Coke is indispensable as a fuel and reducing agent in the making of pig iron; and the distillation or coking of coal yields important by-products such as tar, light oils, ammonia and gas, which serve as raw materials for a great variety of chemicals ranging from explosives to dyes and drugs.[16] Before the first World War virtually all coke was produced in beehive ovens in which by-products were lost. In recent years, however, by-product ovens have contributed all but 2 to 4 per cent of the output—a factor which greatly strengthens our defense economy.

If a serious shortage of coke develops, limited coking facilities will be the reason. The demand for coke is growing rapidly as the steel industry approaches capacity operations; and requirements will be further increased if a relative shortage of iron and steel scrap compels the industry to use a higher proportion of pig iron. By-product ovens are already operating at virtual capacity, and the old, wasteful beehive ovens are rapidly being pressed into service. While beehive coke plants provide a reserve margin[17] and some new and modernized ovens will become available early next year,[18] considerations of national defense may require the construction of additional by-product coke ovens to furnish not only coke, but the raw materials for explosives.

IRON ORE AND SCRAP

The iron and steel industry of the Chicago and Pittsburgh areas[19] would be temporarily paralyzed if a bomb should destroy the locks of the Sault Ste. Marie Canal connecting Lake Superior with the other Great Lakes. About three-quarters of the iron ore mined in the United States ordinarily passes through this canal. It is, however, the only vulnerable point in the supply of iron ore. We probably possess greater ore reserves than any other country.[20]

There is more doubt about the supply of iron and steel scrap, which rivals iron ore in importance as a raw material of the iron and steel industry. In 1939, for example, this country consumed 32,434,407 gross tons of scrap, of which 5.5 per cent was used in blast furnaces, 75 per cent in steel furnaces, and 18 per cent in gray iron foundry cupolas.[21] Modern steel-making practices are built around the use of scrap. In the production of raw steel, scrap replaced pig iron to approximately 56.5 per cent in 1937 and 1938, and to about 54.4 per cent in 1939.[22] The electric furnaces which produce the fine alloy steels use scrap entirely. If the supply of scrap were insufficient, this country would have to build many additional blast furnaces for the production of pig iron, which in turn would demand an increase in the capacity of coke ovens. Such expansion would be costly and time-consuming. At present the pig iron capacity of blast furnaces is only about two-thirds of the raw steel capacity.[23]

The steel industry distinguishes scrap according to origin. It obtains about half of its requirements from "home" scrap, which originates in the steel mills and iron works incidental to the making, shaping and treating of steel and is collected and recirculated through the steel-making furnaces. The remainder must be bought from dealers and is therefore called "purchased" or "market" scrap. In part, this type of scrap accrues as the by-product of manufacturing processes in other industries using

14. Cf. Norman, "Refiners Alert to Potential Needs for Aviation Fuel," cited. The same author predicted in an earlier issue of the *Oil and Gas Journal* (November 30, 1939) that plants under construction and on building programs would raise the production capacity of 100 octane fuel from 270 million gallons per year in 1939 to about 338 million by the end of 1940, and 410 million in 1941.

15. *Energy Resources and National Policy*, cited, Section I, Chapter 3.

16. *Ibid.*, p. 67; also J. W. Weiss, "By-Products of Coal Carbonization," *Industrial and Engineering Chemistry*, September 1940.

17. At the end of 1939 there were still 76 beehive coke plants with 10,934 ovens, of which 58 plants with 8,857 ovens were active. The number of by-product plants was 88, with 13,010 ovens. U.S. Bureau of Mines, *Coke and By-Products, Review of 1939*, pp. 16-17.

18. The U.S. Steel Corporation, for example, is building two batteries of 70 ovens each, and Bethlehem Steel is constructing 76 ovens. *New York Herald Tribune*, September 15, 1940; also *Iron Age*, October 3, 1940, p. 89.

19. Cf. Memorandum of the U.S. Geological Survey, March 7, 1938, *Hearings before a Subcommittee of the Committee on Military Affairs, U.S. Senate, 75th Congress, 3d Session, on S. 2025*, pp. 66-67.

20. U.S. Tariff Commission, *Iron and Steel*, Report No. 128, Second Series, 1938, p. 108.

21. Cf. Institute of Scrap Iron & Steel, *Yearbook 1940*, pp. 1-3.

22. American Iron and Steel Institute, *Annual Statistical Report, 1939*, p. 47.

23. In 1939 the annual pig iron capacity amounted to 54,635,740 net tons, as compared with a raw steel capacity of 81,619,496 net tons. *Ibid.*, pp. 4, 14.

iron and steel, but most of it is derived from the demolition of buildings, ship-breaking and the scrapping of automobiles, machinery, and equipment. Any industrialized country therefore has a large potential source of supply in the form of iron and steel products in current use.[24] The volume in which scrap reaches the market depends, first of all, on the rate of replacement, particularly of capital equipment; and, second, on the price offered for scrap.

No effective step to conserve supplies of scrap for American industry was taken until October 16, 1940, when the government applied an embargo on exports to all countries outside the Western Hemisphere except Great Britain. During recent years the demand for scrap for rearmament brought about huge foreign purchases in this country. In the seven and a half years ending June 30, 1940 total net exports amounted to 18,342,408 gross tons, as compared with only 1,697,083 tons in the entire period 1910-32 inclusive.[25] Consumers of scrap started advocating a curtailment of exports several years ago. The independent steel producers who do not have their own facilities for making pig iron were particularly anxious to restrict exports, pointing out that such shipments were not only increasing the cost of American steel, but depleting our reservoir of scrap faster than it was being accumulated.[26]

The present embargo will hardly prove an effective measure of conservation, because it does not apply to Great Britain and the Western Hemisphere. Britain and Canada together took almost half of the 2,139,000 gross tons of scrap exported in the first eight months of 1940,[27] and in the future will probably seek to buy even more. While the supply of scrap is adequate for the present, the steel industry will need ever larger quantities of "purchased" scrap to carry out the defense program; and in the event of war, the demand will be still greater. There is no likelihood that replacement of capital equipment in the near future will assume such a scale as to bring large supplies of scrap into the market. Because the stocks accumulated in depression years have been depleted by excessive exports, this country would probably be faced, in case of war, with a serious shortage of "purchased" scrap, which would necessitate a collection campaign appealing to patriotism.

MANGANESE

As a purifying and alloying agent, ferromanganese is as indispensable to steel making as iron ore and scrap.[28] While the United States has enough low-grade manganese ore, it has very little that is suitable for ferromanganese. Ore for this purpose usually averages 48 per cent manganese content, though grades of as low as 35 per cent may be used. The production of 60,000,000 long tons of steel requires about 1,000,000 of ferro-grade ore averaging 48 per cent manganese.[29] Under the stress of war, United States mines produced about 35 per cent of our requirements in 1918, but since that time the percentage has averaged well below 10. The Gold Coast in Africa, Soviet Russia, Cuba, British India and Brazil have supplied the bulk of our imports.[30] More recently, substantial quantities have been received from the Union of South Africa.

Although recent investigations have disclosed no new domestic deposits of high-grade ore, they have revealed more substantial reserves of low and medium-grade ore. The concentration of this ore to make it suitable for ferromanganese is very costly; and a large part of it contains too much iron and silica, both of which are difficult to eliminate. In recent years some progress has been made in beneficiating such ores.[31] The most promising commercial method is the "flotation and nodulizing" process applied to the carbonate ores in Montana.[32]

24. It has been estimated that more than one billion tons of iron and steel are in use in the United States. Possibly about a third of this rusts away, or is irretrievably lost; but the remainder comes back on the market as scrap after an average life of 33 years. Cf. American Iron and Steel Institute, *The Picture Story of Steel*, p. 1.

25. The composite price of No. 1 heavy smelting steel scrap rose from an average of $7.54 per ton in 1932 to $18.03 in 1937 and $20.67 in October 1940. Although exports averaged only 11.6 per cent of total domestic scrap consumption during the three-year period 1937-39, they represented 37.3 per cent of the "purchased" scrap used by the steel industry. Cf. *1940 Yearbook of Institute of Scrap Iron & Steel*, pp. 20-21, and American Iron and Steel Institute, *Annual Statistical Report, 1939*, pp. 13, 47.

26. Cf. testimony of Professor Bradley Stoughton, *Hearings before a subcommittee of the Committee on Military Affairs, U.S. Senate, 75th Congress, 3d Session, on S. 2025*, pp. 90, 92.

27. *New York Herald Tribune*, October 15, 1940.

28. Small quantities of very high-grade manganese ore are also required in the manufacture of dry batteries.

29. *Report upon Certain Deficient Strategic Minerals, by the staff of the Geological Survey and the Bureau of Mines*, February 28, 1939, p. 7.

30. In 1939 these countries contributed respectively 242,923, 135,243, 105,935, 89,544, and 42,713 tons to total imports of 627,129 tons. Cf. *Metal Statistics 1940*, p. 67.

31. The Bureau of Mines has developed an electrolytic process which has been commercialized by the Electro Manganese Corporation. Costs are very high, however, and the product, which is pure manganese metal, may not be suitable for ferromanganese. Cf. *Report upon Certain Deficient Strategic Minerals*, cited, p. 6; also *Metal Progress*, October 1940, p. 531.

32. In 1927-28 the Anaconda interests built a beneficiating plant in Butte, Montana, with a production capacity of 70,000 tons of high-grade concentrates per year. In August 1940 they obtained a contract to supply the Metals Reserves Corporation with 240,000 long tons of manganese ore over the next three years, thus enabling them to construct a new $1,000,000 plant which will utilize the latest improvements in beneficiation and produce 100,000 tons yearly. *New York World-Telegram*, August 9, 1940, and *The New York Times*, August 10, 1940.

A similar flotation process has made the low-grade Cuban ores available to the United States.[33] It may also prove possible to get more ore from Brazil, which possesses good deposits in the province of Minas Geraes and still larger, undeveloped reserves in the Matto Grosso. Production, confined to Minas Geraes, has been seriously limited by the inadequate rolling stock and trackage of the Brazilian Central Railway.[34] Although the Defense Commission is considering ways and means of assisting Brazil to improve these transportation facilities, no steps have yet been taken.

While the United States may rely on Cuba, Brazil and domestic mines for larger quantities of ferro-grade ore in the future, these sources of supply will by no means be sufficient. In the circumstances, the stockpiling program recently undertaken becomes doubly important. On August 21, 1940 it was announced that the Metals Reserve Company had already contracted for about 770,000 tons of manganese ore.[35] Early in October 1940 the Industrial Materials Division of the Defense Commission declared that the available supply of manganese would be sufficient for more than two years' requirements.[36] This estimate, however, not only included stocks on hand, but took into consideration supplies obtainable in Cuba and an anticipated rise in domestic production.

OTHER STEEL-ALLOYING METALS

Not only manganese, but many other metals are needed to impart the necessary hardness, toughness, ductility and tensile strength to the special steels required for machine tools, transportation and armament. Of all the ferro-alloys, the United States has a plentiful supply only of molybdenum. In 1939 this country produced 92 per cent of the world's needs, one American mine alone contributing 66 per cent of the output.[37] Nor is there any concern about the supply of vanadium. The metal content of vanadium ores mined in the United States has gone up sharply from 139,512 pounds in 1936 to 1,984,068 pounds in 1939.[38] The balance—about 52 per cent of the total supply in 1939—has come from Peru which presumably would remain accessible even in time of war. Tungsten, consumed primarily in the manufacture of high-speed tool steel vital in the production of armament, presents a slightly more difficult problem. Domestic production, however, has risen from 2,279,369 pounds in 1935 to 4,080,024 in 1939[39] and averaged about 57 per cent of our apparent consumption during the last five years. The bulk of our imports has always come from China and British Malaya. In time of war we may still be able to draw on Argentina and Bolivia, each of which has shown a steady increase in output during recent years.[40] At home we have considerable reserves of tungsten ore which may make us approximately self-sufficient if absolutely necessary.[41] Substantial purchases already made under the stockpiling program will give the United States time to develop its own resources still further.[42] This country produces almost no cobalt, but the small quantity needed for metal cutting and magnet steels could probably be obtained from Canada.[42a]

Compared to the alloying metals mentioned above, nickel and chromium are used in much larger quantities. Nickel and chromium give steel the toughness and hardness which are indispensable in the manufacture of armor plate and armor-piercing projectiles. Although our own nickel production is negligible, and there is little likelihood of a significant increase in the future, a secure source of supply is available in Canada, which produces about 85 per cent of the world's output. It will be far more difficult to obtain adequate amounts of chromite, the ore of chromium. The steel industry uses more than three-quarters of the supply of chromite consumed in this country, either as a refractory material for furnaces or as a metal in making stainless steels and high-strength steel alloys.[43] Chromite also has important uses in the manufacture of chromic acid for electroplating and of chemicals employed in the dyeing, tanning and pigment industries. Since 1920 imports have, on an average, contributed over 99 per cent of the chromite supply in

33. In 1935 a subsidiary of the Freeport Sulphur Company erected a beneficiating plant in Cuba. Its annual capacity will be enlarged from 100,000 to 130,000 tons before January 1, 1941 as the result of an undertaking by the Metals Reserve Corporation to buy from 25,000 to 65,000 tons of its output in each of the next three years. *New York Herald Tribune*, August 17, 1940.

34. H. J. Trueblood, "Raw Material Resources of Latin America," *Foreign Policy Reports*, August 1, 1939, p. 123.

35. *The New York Times*, August 22, 1940.

36. National Defense Advisory Commission, *Press Release 151*, October 8, 1940.

37. U.S. Bureau of Mines, *Molybdenum, Tungsten and Vanadium, Review of 1939*, pp. 1-2.

38. *Ibid.*, p. 17; also *Metal Statistics 1940*, p. 69.

39. Metal content. Cf. *Molybdenum, Tungsten and Vanadium, Review of 1939*, cited, p. 10.

40. *Ibid.*, pp. 14-15.

41. Cf. U.S. Bureau of Mines, *Outlook for Finding Domestic Deposits of Strategic Minerals more Encouraging than Anticipated*, Press Release, June 6, 1940.

42. As part of a transaction whereby the Export-Import Bank lent $25,000,000 to China, the Metals Reserve Company agreed in September 1940 to buy $30,000,000 worth of Chinese tungsten over a number of years. *The New York Times*, September 26, 1940.

42a. U.S. Bureau of Mines, *Nickel and Cobalt, Review of 1939*, pp. 7-8.

43. Cf. U.S. Bureau of Mines, *Chromite, Review of 1939*, pp. 7-9.

the United States. The chief sources have been South Africa, Cuba, Turkey, the Soviet Union, British India, the Philippines and Greece. In time of war we could definitely count only on Cuba, which in 1939 supplied about 16 per cent of our imports.[44] Moreover, Cuban chromite is suitable only for refractory purposes. Although domestic mines contributed only 3,614 tons to the 321,125 tons available for consumption in the United States during 1939, they managed to supply 37 and 44 per cent of our requirements under the stress of war in 1917 and 1918. Much of the chromite deposits in the United States is of very low grade or contains too much iron. A substantial increase in production is possible, however, if cost is no consideration.[45] The most promising chromite reserves have been found in Montana. In an emergency we could do with ore that has a much lower ratio of chromium to iron than is used at present. Meanwhile, the Treasury has bought some chromite for reserve stocks;[46] and the Metal Reserves Company has also made purchases.

As for the more important non-ferrous metals, no serious difficulty is anticipated in the supply of copper, lead and zinc. With the exception of the brief period 1930-32 we have long had an export surplus of copper. Our imports of lead consist largely of ore and base bullion which are smelted and refined in bond and then re-exported in the form of pig lead or manufactured products. We have only a small import surplus of zinc, because of the high cost of domestic mining.[47] In each of these metals we can supply our own requirements, although higher prices would be necessary to satisfy a larger demand than at present. There is a substantial recovery of secondary copper, lead and zinc which tends to increase as prices rise.

TIN

Tin is an ideal food preserver because of its resistance to corrosion by many organic chemicals. Applied as a thin coating to steel, it makes the tin plate from which our tin cans are manufactured.[48] About 43 per cent of the tin consumed in the United States is used for this purpose. Another 40 per cent goes into alloys, particularly solder, but also bearing metals, type metals and bronzes.[49] The remainder is devoted to the manufacture of collapsible tubes, tin foil and to various chemical purposes.

This country has always imported virtually all its tin; and there is no prospect of developing domestic deposits to any significant extent. The available supply could be stretched by conservation and substitution. The first step in the direction of conservation was taken in 1936, when exports of tin-plate scrap were restricted by a licensing system.[50] If necessary, a substantial amount of tin could probably be recovered from used tin cans, none of which now reach detinning plants.[51] The use of tin cans could also be confined to those products for which tin acts as an indispensable preservative; and lacquered black plate might in many cases be substituted for tin plate in food containers.[52] Cadmium, copper, lead and silver could also replace tin to some extent in alloys.[53]

The lack of tin smelters in this country has made it impossible for us to obtain tin from the only important source of supply in the Western Hemisphere—Bolivia, which itself has no smelters and sends its entire ore output to England. The bulk of our tin has come from smelters located in British Malaya, China and the Netherland Indies, and the balance from Europe, particularly Great Britain, the Netherlands and Belgium.[54] Our own tin smelting industry succumbed completely to foreign competition in 1924.[55] Toward the end of 1939 the American Metal Company and the Phelps Dodge Corporation started constructing two small smelters which will use Bolivian ore. Their total capacity, however, will probably not be more than 200 to 300 tons of pig tin per month, or less than 5 per cent of United States consumption. Arrangements for additional smelters had to wait on negotiations with the big Bolivian producers—Patiño, Hochschild and

44. *Ibid.*, p. 6. The percentage is calculated on the chromic oxide content of the ore.

45. Cf. *Report upon Certain Deficient Strategic Minerals*, cited, p. 11.

46. The Treasury is said to have bought 64,500 long tons of chromite by July 1, 1940. Cf. *Mining Congress Journal*, August 1940, p. 40.

47. The Defense Commission is expected to make arrangements with the zinc industry for an increase in smelter capacity sufficient to meet future requirements. Cf. National Defense Advisory Commission, *Press Release 156*, October 10, 1940.

48. Cf. W. A. Janssen, "Tin—an All-Important Strategic Material," *Domestic Commerce Weekly*, September 12, 1940.

49. C. L. Mantell, "Tin," *Industrial and Chemical Engineering*, September 1940.

50. For 1939 the Munitions Control Board authorized a maximum export quota of 15,000 tons. Licenses were actually issued for the shipment of 10,699 tons to Japan—an amount lower than total U.S. imports of tin-plate scrap. Cf. *Tin, Review of 1939*, cited, p. 4.

51. Mr. C. O. Ball, a canning expert, estimated that 10,000 to 20,000 tons of pig tin could be recovered in this way each year. Cf. "Canning Industry," *Industrial and Chemical Engineering*, September 1940.

52. Cf. *Steel*, July 8, 1940, p. 33.

53. Mantell, "Tin," cited.

54. For figures on the sources of imports, cf. *Tin, Review of 1939*, cited, p. 10. In 1939 80 per cent of our imports came from Asia, and 19 per cent from Europe.

55. B. W. Corrado, "Protecting Our Tin Supplies: Bolivian Resources and American Smelters," *The Annalist*, August 8, 1940.

Aramayo[56]—and with the British who usually smelt the Bolivian tin. On November 7 Jesse Jones, Federal Loan Administrator, announced that Bolivian interests had signed a five-year contract with the Metals Reserve Company to supply enough ore concentrates to smelt about 18,000 tons of fine tin annually.[57] The Metals Reserve Company intends either to build a smelter itself, or to contract with some firm to construct and operate a plant. Even if these plans are carried out, they will provide for only a little more than one-fourth of this country's tin consumption. The purchase of reserve stocks is therefore especially imperative.

Until the formation of the Metals Reserve Company by the RFC, buying for stockpiling was insignificant. On June 28, 1940 the Metals Reserve Company concluded an agreement for the purchase of at least 75,000 tons with the International Tin Committee which controls the marketing of most of the world's supply through a system of quotas. The Metals Reserve Company agreed to buy all tin made available at a price of 50 cents a pound, c.i.f. U.S. ports, and to hold stocks accumulated in this way until January 1, 1944. In return, the Committee undertook to raise export quotas for the year beginning July 1, 1940 to 130 per cent of the standard quota, as compared with the 80 per cent rate prevailing in the second quarter of 1940.[58] Although in effect all restrictions on the marketing of tin ore are abandoned by the Committee for one year, there is no assurance that enough tin will reach the market at 50 cents to enable the company to buy the entire amount of 75,000 tons by June 30, 1941, when the agreement expires.[59] If this tonnage is actually purchased, it would represent a little more than the average annual consumption over the last five years.

ALUMINUM AND MAGNESIUM

More than 60 per cent of the structural weight of an airplane consists of aluminum alloy:[60] and the manufacture of 36,000 planes per year—a goal scheduled to be attained by the spring of 1942—would alone require about 231,000,000 pounds of this metal and its alloys.[61] These facts illustrate the vital importance of aluminum to national defense. There has also been a rapid expansion in the use of aluminum in railway and automotive transportation, as well as in high-voltage transmission lines and electrical apparatus.[62]

Magnesium, which is one-third lighter than aluminum, has also been increasingly used in automobile and airplane motors and other types of machinery. The aircraft industry is expected to consume ever larger quantities of this metal, not only for the manufacture of engines, but also for the construction of fuselages and wings.[63]

The supply of raw materials for these two light metals causes no great concern. Magnesium is extracted from underground brines and sea-water. Aluminum is made from bauxite. In the last two years about 55 per cent of this material came from domestic sources, primarily Arkansas; and almost the entire balance was imported from Dutch and British Guiana[64] which probably would remain accessible in wartime.[65]

The real problem lies in creating sufficient capacity for the manufacture of aluminum and magnesium. The Aluminum Company of America, which is the sole maker of primary aluminum, raised its output from 119,295,000 pounds in 1935 to 327,090,000 in 1939, and will probably produce 375,000,000 pounds in 1940.[66] After completing a $26,000,000 expansion program in 1939, it immediately embarked on another, to cost $30,000,000. In September 1940 the Aluminum Company finished a new plant at Vancouver, Washington, which will draw on the Bonneville dam for the large amount of power needed in the reduction of bauxite. Plans

56. These three together contribute about 75 to 80 per cent of Bolivia's tin exports. For a complete review of the Bolivian tin industry, cf. U.S. Bureau of Mines, *Foreign Minerals Quarterly*, October 1939.

57. The company agreed, however, to release a maximum of 6,000 tons of this ore to the British if the latter ask for it, and to "consider" requests for an even larger amount if needed. *New York Herald Tribune*, October 20, 1940; *The New York Times*, November 5, 1940.

58. For the text of the agreement, cf. Federal Loan Agency, *Press Release, 37*, July 20, 1940.

59. By September 14, 1940 the Navy, the Procurement Division of the Treasury and the Metals Reserve Company had bought 13,694 long tons of tin of which more than 8,000 tons had already been delivered (National Defense Advisory Commission, *Press Release 111*, September 20, 1940).

60. U.S. Bureau of Mines, *Bauxite and Aluminum, Review of 1939*, p. 13.

61. This calculation is made from figures on the consumption of aluminum in the average airplane frame, engine and propeller given by Brigadier General George Brett in "Procurement for Defense," *Aviation*, August 1940. It assumes that the average military plane, including multi-engine as well as single engine planes, has 1¾ engines and propellers. According to testimony brought out in the government's anti-trust suit against the Aluminum Company of America, the production of 50,000 Martin bombers would require 800,000,000 pounds of aluminum (*The New York Times*, August 13, 1940).

62. From 1933 to 1938 inclusive 29 per cent of the aluminum supply was used in the transportation industry; 15 per cent in machinery and electrical appliances; 14 per cent in cooking utensils; 10 per cent in electrical conductors; 8 per cent in construction; and the balance for miscellaneous purposes. *Bauxite and Aluminum, Review of 1939*, cited, p. 14.

63. Cf. L. B. Grant, "Magnesium and Its Alloys," *Metal Progress*, October 1940.

64. *Bauxite and Aluminum, Review of 1939*, cited, pp. 5, 9.

65. The Germans have successfully extracted aluminum from a common clay; and a similar process has been discovered by a scientist working in the laboratories of the Tennessee Valley Authority. *Christian Science Monitor*, September 11, 1940.

66. *The New York Times*, August 13, 1940.

for additional facilities during the next two years have been drawn up in collaboration with the Industrial Materials Division of the Defense Commission. The RFC has also lent the Reynolds Metal Company $15,800,000 for the construction of a plant at Sheffield, Alabama, which will have an annual capacity of 60 million pounds and begin operations in July 1941.[67] The Tennessee Valley Authority will expand its generating capacity to provide the extra power required for these projects. The Defense Commission expects that this program will give the United States a productive capacity of 700,000,000 pounds per year. If the output of secondary aluminum, which aggregrated 125,120,000 pounds in 1937 and 77,600,000 in 1938, is taken into consideration, the total will probably be adequate for future needs. Aluminum fabricators are enlarging their facilities at the same time.

Although a number of magnesium patents originated in Germany, this fact has not prevented a rapid expansion in output. Like aluminum, primary magnesium is produced by only one concern—the Dow Chemical Company. In March 1940 this company started building a new plant at Freeport, Texas, which is expected to raise annual capacity from 12 to 25 million pounds by the end of the year.[68] There are already some twenty companies producing magnesium alloys and castings. The leading fabricator, the American Magnesium Corporation, announced in October 1940 that it was planning to triple its output.[69] In view of the sharply rising demand for magnesium, a further expansion in the production and fabrication of this metal may prove necessary.

ANTIMONY, MERCURY AND PLATINUM

These three metals are especially vital to national defense. Antimony, used with lead, imparts the necessary hardness to small arms ammunition and shrapnel; and antimonial lead goes into the manufacture of plates for storage batteries, as well as type and bearing metals. Mercury has a wide variety of uses in drugs, anti-fouling paints, storage batteries, barometers, etc., but particularly in the production of fulminate for high explosives. Recently, however, the development of other detonating compounds, such as lead azide, has promised to relieve the pressure on the mercury supply in time of war.[70] Although platinum still has many important applications in the electrical and chemical industries, it is no longer as indispensable as it was in the first World War.[71]

The supply situation of each of these metals has definitely improved since the last war. Although we have produced less than 11 per cent of our requirements in antimony over the last five years, domestic deposits, particularly in Idaho, are probably capable of a much larger output with rising prices. Moreover, the erection of a primary antimony smelter at Laredo, Texas, in 1935 has enabled this country to draw on the ores of Mexico and Bolivia. The Western Hemisphere has therefore almost completely displaced China as a source of supply.[72] Nevertheless, the sharp increase in consumption expected during war may necessitate the accumulation of some reserve stocks. The Metals Reserve Company is reported to have made small purchases for this purpose.

The domestic output of mercury has increased from 17,518 76-pound flasks in 1935 to 18,633 in 1939, averaging 64.5 per cent of the total new supply.[73] Rapidly advancing prices have brought many new producers into the market. Although this country could undoubtedly supply all of its normal requirements, reserve stocks may be needed to satisfy the wartime demand, which is expected to be about one-third larger.

The initiation of large-scale mining operations in Alaska, financed by the RFC, have been largely responsible for the sharp rise in our output of platinum metals from 11,552 ounces in 1935 to 48,269 in 1938 and 43,760 in 1939.[74] Nevertheless, imports from Great Britain, Colombia, Russia and a number of minor sources still accounted for almost 84 per cent of the total supply of platinum metals in the last two years. Since about 40 per cent is normally devoted to non-essential uses in jewelry and very large amounts of secondary platinum metals are recovered, this country can probably satisfy its own requirements in wartime. If necessary, the large reserves of platinum jewelry could be mobilized.

67. *Ibid.*, October 12, 1940; and *Domestic Commerce, Weekly Bulletin*, October 17, 1940, p. 225.

68. U.S. Bureau of Mines, *Magnesium, Review of 1939*, p. 2.

69. *Iron Age*, October 17, 1940, p. 84.

70. Cf. *Industrial and Engineering Chemistry*, September 1940, p. 1152.

71. Less expensive materials have replaced platinum to a large extent in the contacts and lead-in devices employed in electric light bulbs and electrical instruments. The massive acid stills containing platinum have largely given way to fused silica; and vanadium oxide has supplanted platinum completely as a catalyst in the manufacture of sulphuric acid. U.S. Bureau of Mines, *Minerals Yearbook 1939*, pp. 308-11.

72. Cf. U.S. Bureau of Mines, *Antimony and Cadmium, Review of 1939*, pp. 5-8.

73. U.S. Bureau of Mines, *Mercury, Review of 1939*, p. 2.

74. Palladium, iridium and similar metals are included in this total. Cf. U.S. Bureau of Mines, *Platinum and Allied Metals, Review of 1939*, p. 1.

OTHER MINERALS

As far as the non-metallic minerals are concerned, we are no longer dependent, as in the first World War, on Spanish pyrites as a source of sulphur for the chemical industry. We still import natural nitrates from Chile for fertilizers, but rely on the synthetic product for all industrial uses, including the manufacture of explosives. We have a surplus supply of phosphates; and owing to intensive development of domestic deposits, we can now do without French or German potash. Although the quartz crystals essential for radio and optical instruments are available in Brazil, the government is laying in a reserve supply for emergencies. Domestic sources can furnish only about 5 per cent of the asbestos needed for brakeband linings, clutch facings, heat insulation and construction materials, but the Canadian province of Quebec can produce enough to fill all our requirements.

Graphite and mica offer more difficult problems. Graphite, a crystallized carbon, is used for linings and facings in foundries, for crucibles, paints and pigments, lubricants, pencils, electrical machine brushes, electrodes and dry batteries. Although the United States is still almost entirely dependent on foreign sources, the amount which must come from distant countries like Madagascar and Ceylon has now become only a small fraction of the total.[75] While the United States produces plenty of scrap and ground mica, it supplies virtually none of the high-grade splittings and only 15 to 35 per cent of the sheet mica[76] which are invaluable as insulating material in spark plugs, radio tubes, condensers, and other items essential to communication. Our chief sources are British India and Madagascar, which are favored by a cheap and plentiful supply of labor. At a high cost, domestic production may contribute a larger proportion of our needs. A new product, called Alsifilm and derived from bentonite, a type of clay, may be of increased use as a substitute.[77]

Among the miscellaneous raw materials for which we have been or are dependent on foreign sources are camphor, coconut shell char, and such medicinal and pharmaceutical materials as morphine, iodine and quinine. Our situation with respect to each of these is much better than it has been in the past. We need no longer rely on Japan for natural camphor, used in medicine and the manufacture of nitrocellulose plastics, because our output of synthetic camphor can easily be expanded to take care of all requirements.[78] Coconut shells from distant countries such as the Philippines used to be the primary source of the carbon employed in gas masks to absorb toxic gases and vapors. Today, enough high-grade carbon can be made from wood sawdust, coal and charcoal, provided the necessary plant capacity is erected.[79] The Federal Bureau of Narcotics has enough opium on hand to furnish an adequate supply of morphine for three years.[80] Although we still depend on Java for quinine, abnormally large imports point to the accumulation of substantial commercial stocks in this country. Moreover, certain synthetic products, developed in Germany but already manufactured in the United States, have been proved effective substitutes for quinine.[81] Most of our iodine, used both in medicine and industry, still comes from abroad, especially Chile, but since 1930 we have developed our own industry based on the use of salt brines as raw material. Domestic output can probably be expanded to meet all needs, provided prices are sufficiently high.[82]

RUBBER

One of the most vulnerable points in the defense economy of the United States is rubber. In 1939 we consumed a record total of 592,000 long tons of crude rubber, virtually all of which came from the Far East, and 170,000 tons of reclaimed rubber.[83] Over 70 per cent of the total goes into tires on which our motorized armies and transportation system so largely depend.

While the cultivation of natural rubber in South and Central America is feasible in theory, the present experimental ventures in South America, particularly that of Ford in Brazil, have had only indifferent success owing to the prevalence of a destructive leaf disease and a serious shortage of labor.[84] For the current fiscal year the U.S. Department of Agriculture has obtained a modest appropriation of $500,000 with which it is trying to provide South American natives with rubber plants of good stock and to develop a strain free from leaf

75. U.S. Bureau of Mines, *Minor Non-Metals, Review of 1939*, p. 2.

76. U.S. Bureau of Mines, *Mica, Review of 1939*, p. 14.

77. *Ibid.*, p. 17.

78. J. K. Hunt, "Synthetic Camphor," *Industrial and Engineering Chemistry*, September 1940.

79. A. B. Ray, "Activated Carbon," *ibid.*

80. E. H. Volwiller, "Pharmaceutical Manufacture," *ibid.*

81. *Ibid.*; also *The New York Times*, July 7, 1940. The products in question, atabrine and plasmodrin, are being manufactured in this country by the Winthrop Chemical Company which acquired unrestricted rights from Germany.

82. G. A. Roush, *Strategic Mineral Supplies* (New York, McGraw-Hill, 1939), p. 393.

83. *The Rubber Age*, September 1940, p. 422.

84. P. W. Barker, "Rubber—A Strategic Raw Material," *Domestic Commerce Weekly*, September 15, 1940. At present only 1.4 per cent of the world area devoted to plantation rubber is located in Africa, and South and Central America.

disease.[85] It has been suggested that quicker results might be achieved with guayule rubber shrubs, which are native to our own Southwest and Mexico and take only three to five years to mature, as compared with at least five years for a rubber tree.[86]

Germany has proved that synthetic rubber can be a reliable source of supply in times of emergency. Today up to 90 per cent of the composition of tires made in that country consists of buna, a synthetic product.[87] In the United States the synthetic rubber industry is only in its infancy. At present synthetic products cost about 65 cents a pound, as compared with a current price of 20 cents for natural rubber. They are sold today only because of certain superior properties, such as resistance to combustion, heat and oil, which make them preferable for a limited number of industrial uses.

In 1939 production of synthetic rubber in the United States amounted to 1,700 long tons, or less than 0.5 per cent of the consumption of crude rubber. Expansion programs undertaken by the du Pont, Standard Oil, Goodyear, Goodrich and Firestone Companies are expected to raise annual capacity in the near future to between 13,000 and 15,000 tons.[88] The erection of production facilities sufficient to satisfy half of our current consumption of crude rubber would require an investment of close to 150 million dollars. It could probably be done best in units of 35,000-ton capacity, which would take about 18 months to construct.[89] Although large-scale production might reduce costs to 25 cents a pound,[90] synthetic rubber still could not be turned out on a competitive, commercial basis for use in tires as long as natural rubber is available. If the government wants to increase production substantially, it will not only have to finance the plants, but buy the output at cost prices.

The time lag in stepping up the output of synthetic rubber has made accumulation of reserve stocks all the more imperative. By September 28, 1940, the government had received 50,425 of the 85,000 long tons of rubber to be delivered under the cotton-rubber barter deal concluded with Britain in June 1939.[91] On June 29, 1940 the Rubber Reserve Company of the RFC signed an agreement with the International Rubber Regulation Committee, undertaking to buy a stock of 150,000 tons of rubber by the end of 1940 at a price between 18 and 20 cents a pound. In return, the Committee undertook to encourage producers to sell the necessary quantities at this price range.[92] In August a similar arrangement was reached for the purchase of 180,000 tons during 1941 at comparable prices.

In an emergency the use of reclaimed rubber, which currently represents one-third of crude rubber consumption, could easily be expanded, perhaps to about 300,000 tons.[93] In addition, the available supply could be rationed to conserve it for the most essential uses. Considering these factors, the United States could probably dispense with imports for two years, provided the Rubber Reserve Company can carry out its present stockpiling program and ordinary commercial reserves of 300,000 tons are maintained.

FIBERS AND LEATHER

The supply of fibers for national defense may give some trouble. We depend on the Philippines for the manila fiber needed for marine cordage, oil-well cables and construction work. In some cases high-strength rayon might be used as a substitute.[94] All our silk comes from Japan, but only a part of the usual imports would be required for indispensable uses such as cartridge bags and parachute cloth. Moreover, recent experiments indicate that nylon would be a satisfactory substitute for these purposes.[95] We may run short of cotton linters for the production of explosives and rayon, but could employ highly refined wood pulp in their place.[96]

To clothe an army of over a million men requires an enormous amount of cotton and wool. While this country has plenty of cotton for military and civilian needs, it has in the past five years imported about a third of its consumption of apparel wool, primarily from Australia, New Zealand, Argentina and Uruguay. Even the Latin American sources are far away, and cannot, in any event, meet the entire deficit. For this reason, the National Defense Advisory Commission has persuaded the British government to store 250,000,000 grease pounds of Aus-

85. *The Rubber Age*, September 1940, p. 396.

86. Barker, "Rubber—A Strategic Raw Material," cited.

87. Cf. *Hearings before the Committee on Military Affairs, U.S. Senate, 76th Congress, 3d Session on S. 4082*, June 14, 1940.

88. *Ibid;* also articles by Bevis Longstreth, E. R. Bridgewater and E. V. Murphree, *Industrial and Chemical Engineering*, September 1940; and *The New York Times*, September 9, 1940.

89. Cf. estimate of J. L. Collyer, president of Goodrich, *The New York Times*, October 9, 1940.

90. *Ibid.*

91. U.S. Department of Commerce, *Rubber News Notes*, October 16, 1940.

92. For text, cf. Federal Loan Agency, *Press Release 37*, July 20, 1940.

93. A survey in 1937 showed a potential capacity for the production of 265,000 tons, which could be rapidly increased. *The Rubber Age*, July 1940, p. 252.

94. *The Textile World*, September 1940, p. 89.

95. *Ibid.*, p. 87. Cf. also article by J. K. Hunt, *Industrial and Engineering Chemistry*, September 1940.

96. G. A. Richter, "Wood Cellulose," *Industrial and Engineering Chemistry*, September 1940.

tralian wool in the United States. This amount, which is slightly larger than our average annual import surplus during the last five years, will be held as a reserve supply available only in case of emergency.[97]

Despite this arrangement, army requirements for woolen blankets and clothing might prove so great in wartime that civilian consumption would have to be curtailed. While cotton could in some cases be used as a substitute, the greater part of the deficiency would have to be met by increased use of rayon and staple fibers, many of which have qualities similar to those of wool. Such substitution would in turn put a heavy strain on the supply of wood pulp, the raw material for these synthetic fibers. Although we normally import about a fifth of our total consumption of pulp for paper and rayon, we have become increasingly self-sufficient. With the aid of supplies from Canada, we have been able to dispense with imports from Scandinavia. Domestic production capacity for rayon pulp is at present adequate, and additional amounts could be made available by diverting part of the pulp used for coarse papers to the manufacture of rayon.[98]

The Duke of Wellington once said that a good pair of shoes was the foremost requirement of a soldier. To provide enough leather for boots and shoes, gloves, harness, saddles, belts, leggings, straps, etc., is no simple task. In the last five years the tanning industry of the United States had to import about a third (by value) of its raw materials, including hides, skins and tanning materials. Approximately half of the vegetable tannin used in making leather came from foreign countries, primarily Paraguay and Argentina. Today, however, chemical or chrome tanning is employed in the production of 65 per cent of all leather. Imports have accounted for about 12 per cent of the cattle hides, 24 per cent of the calf and pig skins, 59 per cent of the sheep and lamb skins, and all the goat and kid skins consumed in the United States during the past five years.[99] The Western Hemisphere can supply the bulk of this country's import requirements. South America, particularly Argentina, and Canada could meet the deficit in cattle hides needed for shoe leather. The Latin American export surplus of sheep and lamb skins exceeds our normal imports by a considerable margin. Most of our calf and kid skin imports, however, have come from Europe, and the search for other sources of supply has not yet been successful. Latin America could cover only a third of our goat and kid skin requirements, but these skins are less indispensable for military purposes.[100] Since the more important South American sources—Argentina and Uruguay—are rather distant, and both Far Eastern and European supplies may be cut off, the United States may have to curtail civilian consumption of leather in wartime.

A LAND OF PLENTY

With few exceptions, the United States has an unrivaled supply of the materials essential to national defense. On the whole, this country has become more self-sufficient. In 1914 the outbreak of war created critical problems of supply; this time, on the other hand, it has proved comparatively easy to adjust our economy to the wars in Europe and the Far East. We have further developed our natural wealth, and chemistry has opened up new resources. Latin America has become an increasing source of supply. The government is carrying out plans to meet most of the critical shortages that remain, not only through restriction of exports but, above all, through an extensive, if somewhat belated, stockpiling program. Only the outbreak of war in the Far East can prevent us from laying in needed reserves of rubber, tin and a few other strategic materials. Compared to that of other countries, moreover, our standard of living is so high that substantial quantities of materials could be released for military purposes through a relatively slight curtailment of civilian consumption. Germany has demonstrated, however, that the capacity to wage war is not necessarily commensurate with industrial power or natural wealth. As the example of Britain and France has shown, there is a wide gap between possession of ample resources and their effective utilization for war. The chief task for the United States is to see that our vast potentialities for defense are fully realized.

97. National Defense Advisory Commission, *Press Release 157*, October 10, 1940.

98. A process for converting kraft pulp into rayon pulp is now known. Cf. Richter, "Wood Cellulose," cited.

99. Figures furnished by the Leather and Rubber Division of the Bureau of Foreign and Domestic Commerce.

100. Cf. J. G. Schnitzer, "Leather—A Unique Material," *Domestic Commerce, Weekly Bulletin*, October 3, 1940.

The December 1 issue of FOREIGN POLICY REPORTS *will be*
THE UNITED STATES ARMY IN TRANSITION *By David H. Popper*